

NORWAY SPRUCE PLANTATIONS IN CROATIA: INVESTMENT ANALYSIS AND ALTERNATIVES

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Abstract: *Spruce plantations in Croatia were established mainly during the second half of the 20th century. Reasons were karst afforestation and increase of short term profit. As skiofit species it tolerates high planting density and thus provides high timber volume at the end of rotation. Planting density, spatial distribution, thinning intervals and intensity are key elements of economical management. End of rotation has the most influence on economic result because it is the time of highest net profit. The comparison of one long or several short rotations in the same time period represents different opportunity costs. This paper presents investment analysis in spruce plantations. Revenues and costs are estimated for each tree separately in particular plantation. Using forest growth simulator MOSES version 3.0 optimal rotations have been evaluated based on silvicultural and economic criteria. The results show the most profitable management scenario for growing spruce trees in a defined time period.*

Keywords: capital budgeting, plantations, management scenario, rotation length, NPV, LEV

INTRODUCTION

In Central Europe, Norway spruce has had a long history of cultivation since the middle of the 19th century. This species has been planted intensely thus has changed natural forest into artificial forests and has led to the introduction far outside its natural range. But in many European countries, the choice of tree species is changing. Norway spruce for example has been shifted to be mixed with broadleaves. According to Spiecker (2002), mixed stands have been found to be more resistant against various forms of damage, more diverse in their fauna and flora composition than pure, single-species stands.

Forest management has had a long tradition in the Republic of Croatia, and it is traditionally oriented to the so called close to nature forest management. Major establishment of forest cultures began in the last century with sanation of water torrents, afforestation of lower karst areas (pinus), higher karst areas (spruce) and low land areas with populus plantation. Coniferous cultures cover 1.44% of Croatian forests area, which is 28680 ha in surface (Čavlović 2010). Norway spruce is a species which dominates Croatian forest cultures. Spruce cultures are established on different terrains, from lowland to the mountain areas (Matić 2011). Fast growth wood production from artificial coniferous plantations, became more attractive as a consequence of higher demand for the woody biomass. Forestry as an economic branch has specific tasks in management plans and financial accounting. It is not always possible to respect principles of current profitability, as omission of certain forest interventions can impact the future woody biomass increment and reduce forest value, which can have long term negative consequences on profitability (Posavec 2002).

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Capital budgeting or investment analysis is a decision making procedure about long term investment in a company's business assets, as a long term investment project.

Capital budgeting techniques have been the principal means of analysis of timber investments. These techniques discount the values of costs and returns to calculate present values, land expectation value, cost/benefit ratios or internal rate of return (Zinkhan 2003). It is the process of making a decision about the financial desirability of a project (Dow 2009, Klemperer 2003, Sheffin 2003). Planting density, spatial distribution, thinning intervals and intensity are key elements of economical forest management. End of rotation has the most influence on economic result because it is the time of highest net profit. The comparison of one long or several short rotations in the same time period represents different opportunity costs (Yin 1997). The basic characteristic of an investment is that the benefit is not immediate but postponed in time. Investments are in fact prolonged present expenditures, because of higher expenditures in the future (Orsag 2002, Ravenšćak 2012). Currently prescribed rotation period for natural spruce forests is 80 years, irrespective of stand quality (productivity options), while rotation period for cultures is defined through forest management plan (Annon 2006). There are two main aims of spruce stands establishment: first, ecological aim is habitat development and enabling recovery of natural indigenous forest vegetation; second, economic aim is the highest possible woody biomass production. These goals can be reached through two or more culture generations depending on degree of forest stand quality damage.

Business results and set goals depend directly on the length of rotation period and therefore the aim of this paper is to research possibilities of implementing prescribed natural forest rotation period for use on cultures and defining the most profitable rotation scenario within the 80 year period. The comparison of one long or several short rotations in the same time period represents different financial result. The paper compares profitability of one 80 year long rotation to combined rotations of different lengths whose total is also 80 years (for example, profitability of one 80 year rotation vs. two 40 year rotations).

1 MATERIAL

Spruce is one of the most common and economically important coniferous species in Europe. Its good yield and quality performance on very different site conditions favored this species over a long period (Tjajadi 2010). The center of common spruce distribution are higher mountains of central and northern Europe. Therefore it does not establish important forest zone in Croatia as it is the case with beech or sessile oak for example (Alegro 2000). Norway spruce in Croatia is a species that naturally grows in valleys and frost spots of high mountains in which it does not have serious competition of other tree species (Matić 2011). In total growing stock of Croatian forests, spruce makes 2 380 578.00 m³, that is 273 m³/ha. There are 8 363.72 ha of spruce plantations in the Republic of Croatia which makes 30% of total surface of coniferous plantations (Čavlović 2010). Average growing stock in plantations is 109.2 m³/ha. Object of the research is situated in central Croatia, in the area of largest formation of pure spruce cultures during 1950's and 1960's. Experimental plot is located in the area of Forest district of Karlovac, forest office Duga Resa within a stand (surface 8,73ha) of young spruce culture with other indigenous broadleaved species (common hornbeam, sessile oak) whose growing stock is negligible in comparison to spruce. The trees are healthy, of good quality and uniform dimensions. The terrain is mildly hilly and partly rocky, with altitude oscillating between 165-185 m. An experimental plot of 1 hectare (100x100m) was allocated within the stand. The culture was established 20 years ago by planting four year old seedlings at a distance of 3x3.5 m that allows for later start of thinning. The growing stock measured on experimental plot is 122.79 m³/ha, and current annual increment 6.5m³/ha. Mean

tree size is 15.5 cm in diameter and 13.2 m in height (crown height is 7.1m). For calculation of mean tree size volume Schumacher–Hall function was used (Schumacher 1933). The researched culture is managed with the 80-year rotation period prescribed for natural spruce forests. In the past, cultures were managed with different rotation period lengths, mostly between 40 and 100 years, depending on stand quality of habitat and defined management aim. Cycle thinning does not depend on rotation period and it amounts 10 years, with first thinning done at 30 years of age.

2 METHODS

Stand value grows over time. To estimate current value of forest stands the method of the present cut value is used (Figurić 1996). Using data of growing stock with assortment tables and price lists for the year 2012, classification by age and worth is made. Price list is available at <http://portal.hrsume.hr/>. Labor and culture establishment costs in forest exploitation were also taken into account (Anon 2008). The estimated economic value of the existing growing stock and economic value of assortments harvested in thinning is presented in Results. The economic value of forest can be calculated from the selling prices of timber assortments. In this method of determining the economic value, forest is considered as a final product that can be cut and sold immediately. Consequently, this method is often recognized in literature (Figurić 1996) as value of forest stand which is cut and sold at any age. To calculate stand value it is necessary to establish its growing stock and proportion of individual assortments. By using the method of current cutting value, stand value for each 10 year period was calculated. Current condition at 20 years of age was measured on site.

Current growing stock, height, crown height, breast height diameter (BHD) and spatial distribution for each tree were measured on experimental plot (size of 1 hectare) and imported in Forest Growth Simulator MOSES ver. 3.0. (Hasenauer 2000). Models of height and diameter increment used in simulator were constructed for Austrian conditions (BOKU). Its outputs were used as basis for investment analysis in the research. MOSES represents the diversity of age and species in that it is possible to assess consequences of treatment strategies depending on the position of each individual tree within all-aged pure and mixed stands (Hasenauer 1994, Pretzch et al. 2002). It consists of different sub-models (diameter increment, height increment, crown, mortality). The current annual height and diameter increment are calculated depending on the potential height, potential diameter increment and a dynamic growth reduction function (crown ratio) representing changing growth conditions and competition. Potential diameter increment is defined by functions of open growth trees (Hasenauer 1997). In this research, each simulation was done by using the same increment models; therefore the comparison of scenarios between themselves is justified. Prescribed management of spruce cultures instigates thinnings every 10 years which was also done in the simulator. The projection implies establishing next generation in the same year in which the previous culture was cut. The 80 year time frame represents duration time of investment project within which 8 scenarios were defined for research purposes. Simulations comprise 8 different scenarios of culture management over 80 year period. Wood exploitation revenue and expenses were calculated for each thinning and cutting. The shortest used rotation period is 20 years, and the longest 80 years, while 40 year and 60 year rotation was also used (Table 1). The growth scenarios with different rotation periods use projected development from the basic first scenario and are combinations of its elements. The common point to all scenarios are thinnings every 10 years, starting from 30 years of age, meaning that rotation period of 20 years implies 20 years of management without thinning.

Tab. 1 Management scenarios

Scenario No.		1	2	3	4	5	6	7	8
Rotation period combination	[years]	80	40	20	40	20	20	60	20
			40	20	20	40	20	20	60
				20	20	20	40		
				20					

For each individual tree, assortment structure was established and wood value calculated. Cutting, processing and transportation costs were taken from the company price list of Hrvatske šume Ltd. (Annon 2008). Thinning intensity was determined according to the book of regulations of forest management (Annon 2006) according to which the thinning annual cut of intermediate profit is determined by formula 1 (Klepac 1963).

$$E_m = M \cdot \left(1 - \frac{1}{1,0p^l}\right) \cdot \frac{1}{q} \quad [1]$$

E_m – cut [m³]

M –growing stock [m³]

P –current annual increment [%]

l – interval of thinning [year]

q – realization factor

Realization factor (q) is determined by the growing stock and stand age, referring to the proportion of cut against accumulated increment. In case when $q=3$ there will be cut 1/3 of volume increment in the stand from the last management period (m³). In a stand of normal growing stock, realization factor is directly connected to stand age. In young stand (30-40 years of age) realization factor 2 was used, in middle aged stand (50 years) factor 3, and in ready-to-cut stands (60-70 years) factor 4. First thinning was done at 30 years of age and the last at 70 after which clear cut followed at 80 years of age. The experimental plot is situated at the first site index, which is in direct connection with potential tree height taken from the yield tables for pure spruce cultures of first stand quality (Meštrović 1995). Potential stand quality height is 33m, used as an entry data, and it represents maximum height that a tree can obtain in competition free conditions. This variable is of crucial importance in the work of simulator because it influences the annual net increment.

The basic criteria for evaluating scenarios are Net Present Value and Land Expectation Value where forestry interest rate of 1.5% was used. In economics, the Net Present Value or net present worth (NPW) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows of the same entity (Lin 2000, Klemperer 2003). If the NPV of a prospective project is positive, it should be accepted. NPV is a central tool in discounted cash flow (DCF) analysis and is a standard method for using the time value of money to appraise long-term projects. This method will be used as a major tool in scenario ranking. The Land Expectation Value is the maximum an investor can invest in the land asset and still earn the minimum acceptable rate of return on the invested capital. The decision criterion is to accept the investment if the LEV is positive. LEV is sometimes also called the Faustmann formula. It is the present value, per unit area, of the projected costs and revenues from an infinite series of identical even-aged forest rotations (Klemperer 2003).

4 RESULTS

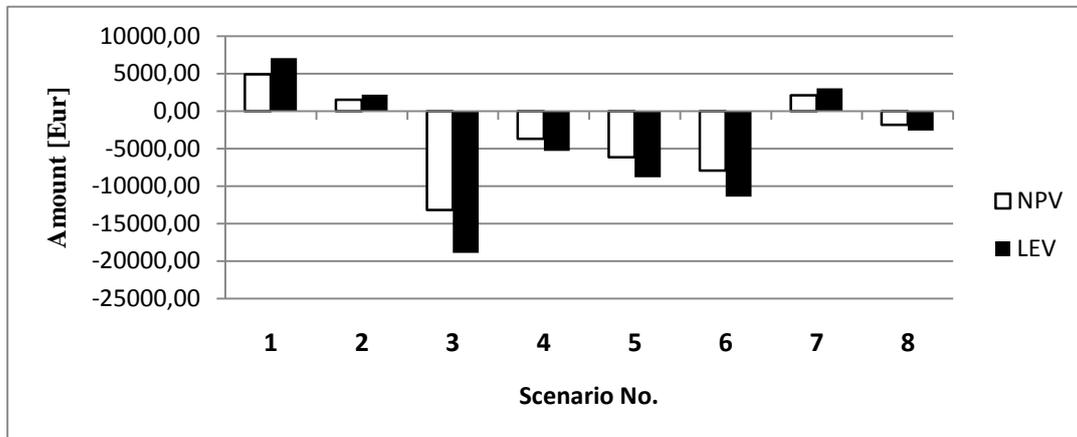
Stand development is projected from 20 years of age until the end of rotation period (80 years). A stand at 80 years of age would have 332 trees per hectare, a basal area of 44 m²/ha and 622.6 m³/ha of growing stock (Table 2). Elements of stand structure projected according to scenarios are the result of stand development at a particular age of the first scenario (Tables 1 and 2).

Tab. 2 Stand growth dynamics

age [year]	20	30	40	50	60	70	80
N [pcs/ha]	986.00	904.00	631.00	527.00	435.00	371.00	332.00
G [m ² /ha]	18.60	30.99	33.36	38.19	40.32	41.93	44.24
V [m ³ /ha]	125.63	255.63	323.02	420.18	490.59	553.21	622.60
CAI [m ³ /ha/year]		13.00	6.74	9.72	7.04	6.26	6.94

Costs of establishing a spruce culture are equal for each scenario and amount to 6492.53 €. Cost-revenue ratio is different in relation to individual scenarios (Table 3). Establishing cost implies the cost of seedlings and the price of labor during afforestation according to sales prices of Hrvatske šume Ltd. (Annon 2008). At the end of the observed period, the highest profit is seen in the first scenario. All scenarios except first include starting costs twice or more (Table 1 and 3). The basic criteria for accepting projects are the positive results value of NPV and LEV methods.

Figure 1 Investment analysis using NPV and LEV



The results indicate that scenarios 1, 2 and 7 are economically acceptable for managing spruce cultures in the future. Economic effects of scenario 3 application would, as expected, be the least satisfactory, owing to short rotation periods and resulting in frequent artificial rejuvenation and negative revenue-cost ratio. It is interesting to note that scenarios 4 and 8 obtain very similar financial results although they differ greatly in the length of chosen rotation periods (Figure 1). The Net Present Value refers to the time duration of an 80 year project, while the Land Expectation Value implies the infinite number of identical projects. Management through application of scenarios referring to combination of short rotation periods (scenarios 3,4, 5 and 6) result in production of assortments of small dimensions and thus of small realizable value. Quantitatively speaking, a larger amount of less valuable

assortments is produced in a short time period, but the time preference variable does not have substantial influence on the business result (Figure 1).

Tab. 3 Scenario analyses

Scenario No.	[Euro]	Project age [year]								
		0	10	20	30	40	50	60	70	80
1	Net Revenue	1988.82 1253.31 1900.29 1489.38 1420.31 24520.03								
	Afforestation costs	6492.53								
2	Net Revenue	1988.82 11272.74 1988.82 11272.74								
	Afforestation costs	6492.53 6492.53								
3	Net Revenue	2187.31 2187.31 2187.31 2187.31								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								
4	Net Revenue	1988.82 11272.74 2187.31 2187.31								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								
5	Net Revenue	2187.31 1988.82 11272.74 2187.31								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								
6	Net Revenue	2187.31 2187.31 1988.82 11272.74								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								
7	Net Revenue	1988.82 1253.31 1900.29 18948.54 2187.31								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								
8	Net Revenue	2187.31 1988.82 1253.31 1900.29 18948.54								
	Afforestation costs	6492.53 6492.53 6492.53 6492.53								

The negative result is due to the fact that short rotation periods do not allow for culmination of volume increment. In Norwegian spruce stands, the culmination of volume increment, or the absolute maturity is reached at 90 years of age (Delač 2012). The third scenario uses the combination of the shortest, 20 year rotation period, at which a stand has not even reached culmination of height increment (Table 1). The first scenario is the most profitable, while the third is the least profitable (Figure 1). The prescribed 80 year rotation period that is practiced in Croatian forestry for natural spruce forests, in this paper described as scenario 1, justifies its use in culture management due to its profitability. All other scenarios that are combinations of short rotation periods are financially less favorable as stands do not reach the age of absolute maturity.

5 CONCLUSION AND DISCUSSION

Investment in spruce culture with its cultivation characteristics is financially justified. Cultures of short rotation periods offer possibility of higher turnover in shorter time period, increasing cost effectiveness of an investment. It is particularly useful in conditions of small contribution of cultures in total forest surfaces, with the aim of reviving of indigenous forest vegetation to degraded stands and afforestation of abandoned agricultural areas.

Investment analysis suggests forest management by using the first scenario. Other scenarios that use rotation periods closer to the absolute stand maturity are more profitable as a result of maximum average increment in the analyzed 80 year period. Average log diameter also has a significant influence on wood value, i.e. the average diameter that increases profitability of longer rotation periods because they are closer to the economic maturity or maximum growing stock value.

Besides the current woody biomass production potential in state forests (2.6 mil m³), there is an opportunity for production increase through establishment of new fast growing forest cultures at 180 000 ha on average. Forest biomass exploitation for energy purposes in Croatia

could have multiple socio-economic benefits and represents a possibility for rural development. In this context, the evaluation of scenarios was done solely based on revenue from wood value, with assumption that ecological benefits are equal for all scenarios. But it is also a known fact that longer rotation periods benefit increase of biodiversity and non wood forest functions (Hartley 2002).

Further investment analysis is possible in direction of analyzing particular investments by forest management segments. It is possible to explore cost effectiveness of longer/shorter thinning rotation period application. Thinnings done on young stands are not cost effective, because labor and machinery costs overcome sales revenue of wood assortments, and they can be avoided by planting a smaller number of trees by surface unit. On the other hand, application of thinning on young stands, as well as investing in branch pruning, results in production of more valuable assortments at the end of rotation period. In this paper, investment analysis until 80 years of age was researched, but it is necessary to explore possibilities of cutting age prolongation for spruce cultures.

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